

**NASA Glenn Research Center
Acoustical Testing Laboratory**

OFFICIAL LABORATORY REPORT

ATL-04-05

On

**Fluids and Combustion Facility
Flight Combustion Integrated Rack**

Date: 04/13/2005

**For: ZIN Technologies
2001 Aerospace Parkway
Cleveland, OH 44142**

Contents:

**Measurement of Emission Sound Pressure Levels at a Work Station and
at Other Specified Positions**

In accordance with

ISO 11201 (1995-12-15) and NASA Document SSP 57000G

Report Contents:

- **1/1Octave Band Sound Pressure Levels**
- **A-Weighted Sound Pressure Levels**
- **NC Levels**

**The NASA Glenn Research Center Acoustical Testing Laboratory is
NVLAP-Accredited for the ISO 11201 Test Method**

<p>National Institute of Standards and Technology</p>	 <p>NVLAP Lab Code 200557-0</p>	<p>National Voluntary Laboratory Accreditation Program</p>
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INTRODUCTION

The Fluids and Combustion Facility (FCF) Flight Combustion Integrated Rack (CIR), as manufactured by ZIN Technologies was tested at the NASA Glenn Research Center Acoustical Testing Laboratory in Cleveland, Ohio, on April 11 – 18, 2005. Measurements were conducted in full conformance with ISO 11201 and NASA Document SSP 57000G. The NASA Glenn Research Center Acoustical Testing Laboratory is NVLAP accredited for the ISO 11201 test method. The NASA SSP 57000G Interface Requirements Document is not a test method and is not available for accreditation by NVLAP. Therefore the analysis of the sound pressure level data and comparison with the criteria outlined in NASA SSP57000G is NOT accredited by NVLAP.

The tests were conducted by James Akers, PhD, Laboratory Test Engineer, and Paul Passe, Facility Engineer, under the supervision of Beth Cooper, Laboratory Technical Manager. Data analysis and report generation was conducted by James Akers, Ph.D.

REFERENCES

The tests conducted and reported on herein were conducted in accordance with the guidelines of the following standards:

ISO11201 (12-15-1995 edition) - Noise emitted by machinery and equipment-Measurement of emission sound pressure levels at a work station and at other specified positions-Engineering method in an essentially free field over a reflecting plane.

NASA Document SSP 57000 Rev G (9-4-2003 edition) – Pressurized Payloads Interface Requirements Document, International Space Station Program.

TEST METHOD

The measurements were conducted in a hemi-anechoic chamber with dimensions between wedge tips of 6.4 m (21 ft) X 5.0 m (16.5 ft) X 5.2 m (17 ft) hemi-anechoic chamber in accordance with the methods outlined in ISO 11201. This chamber has been qualified in accordance with the procedures of ISO 3744, Annex A and has been demonstrated to have a $K_{2A} < 2.0\text{dB}$ from 100 Hz to 10 kHz, as required by section 6.2 of ISO 11201.

An array of twenty-two (24) fixed microphones was used to conduct measurements on the front surface of the DUT. Twenty one (21) of the microphones were located on approximately 0.3 m (12") vertical centers, 0.36 (14") horizontal centers and at a distance of 0.6 meters (24") from the DUT. Three microphones were added to the array when the ATL test procedure determined that the twenty one (21) position fixed array did not coincide with the position with the highest sound pressure level at a distance of 0.6 meters from the DUT. The Fire Extinguisher microphone, position #22, was converted into a roving microphone and relocated 0.6 halfway between positions #7 and #14. The Compliance Verification Point microphone, position #23, was located 6 inches below the Fire Extinguisher microphone, position #22. The External Reference microphone, position #25, was converted into a roving microphone and located halfway between microphone positions #14 and #21.

An array of twenty two (22) fixed microphones was used to conduct measurements on the side, back, and top surfaces of the DUT. Six (6) microphones were located on the left and right sides with two columns of three microphones with a 17 inch horizontal spacing and a 24 inch vertical spacing. Six (6) microphones were located on the back side in two columns of three microphones with a 21 inch horizontal spacing and a 24 inch vertical spacing. Four (4) microphones were located on top in a 2 x 2 configuration with a 16 inch spacing front-to-back and a 21 inch spacing left-to-right. All microphones were at a distance of 0.6 meters.

TEST EQUIPMENT

A National Instruments 455x based Digital Signal Analysis System was used in conjunction with seventeen (17) Bruel and Kjaer type 4189 ½" free field microphones with 2669 pre-amplifiers, and eight (8) Bruel and Kjaer type 4189 ½" free field with 2671 pre-amplifiers to make all measurements reported herein. National Instruments Sound Power Systems software and Nelson Acoustical Engineering Multi-Channel Real-Time Analysis software was used to operate

the digital analyzer hardware and automate the data acquisition process. All instruments carry current calibration certificates traceable to the National Institute of Standards and Technology.

ENVIRONMENTAL CONDITIONS

At the time of the tests reported on herein, the following environmental conditions were measured in the laboratory:

Temperature(C)	Relative Humidity(%)	Pressure (kPa)
23.7	37	98.9

DEVICE UNDER TEST

The Device Under Test (DUT) consisted of the Fluids and Combustion Facility (FCF) Flight Combustion Integrated Rack (CIR). A detailed description of the DUT can be found in the ATL test report for this test, ATL TR-04-05.

- The DUT was supported with a Rack Handling Adapter (RHA).
- The major dimensions of the combined DUT and RHA were 1.07 x 2.82 x 1.91 (width x depth x height in m).
- The combined weight of the DUT and RHA was approximately 1360 kg (3000 lb).
- The DUT in the RHA was placed on the floor (the reflecting plane) of the hemi-anechoic test chamber.
- Melamine foam was placed directly under the DUT between the legs of the base of the RHA.
- The DUT squarely faced the south wall of the test chamber. The front of the DUT was 2.36 m from wedge tips on the south wall of the test chamber. The right side of the DUT was 2.67 m from the wedge tips on the east wall of the test chamber.
- The DUT water chiller and power supply were located in the adjoining test enclosure. The water hoses and power cable passed through utility penetration ports in the west wall of the test enclosure and east wall of the test chamber. The water hoses and power cable, inside the test chamber, were wrapped in pipe lagging material.
- The computers that controlled the DUT were located outside the test chamber in the hallway next the to the test chambers double doors. The computer cables passed through a utility penetration port in the north wall of the test chamber.

DATA ACQUISITION AND ANALYSIS

The tests reported on herein were conducted and the data obtained was analyzed in the following manner:

- Ambient sound pressure levels were measured in 1/3 octave bands at each microphone location.
- The DUT was placed at the test location and in the desired operating condition. The Source-On sound pressure levels were measured in 1/3 octave bands simultaneously at each microphone location. Each microphone was sampled for 60 seconds or one full operational cycle, whichever was greater.
- The sound pressure level at each position was corrected for ambient noise interference as described in section 6.4, equation (3).
- The position with the highest A-weighted sound pressure level on the front surface of the DUT was determined.
- The 1/3 octave band sound pressure levels at the highest A-weighted position were energy summed to create octave band sound pressure levels.
- The Noise Criteria Level associated with the position with the highest A-weighted sound pressure level was computed.

RESULTS

Results of the Sound Pressure Level tests are summarized in terms of A-weighted Sound Level, L_{PA} , and the estimated NC-Rating at the microphone location in front of the DUT with the highest A-weighted Sound Level for this mode of operation. Sound Pressure Level results are expressed in decibels with a reference level of 2×10^{-5} Pa. Octave band results are reported in the attached tables and graphs.

Test Number	Operating Condition	Highest Sound Level (L_{PA})	NC-Rating (Est'd)
ATL-04-05	Continuous noise sources on ATCU Fans @ 2300 rpm	51 dB(A)	46

Signatures Removed For Web Posting

Respectfully Submitted: _____

James Akers, Ph.D. Laboratory Engineer
Data Acquisition, Analysis and Report

Beth Cooper, Laboratory Technical Manager
Report Review and Approval

ISO 11201 / NASA SSP 57000 Rack Front Noise Emission Test Data Sheet

Report Date: 4/13/2005, 1:12 PM

Test Information		Source Information	
Test Name	CIR F 06 Amb-All Quiet 04 So	Source Type	0
Test Date/Time	4/13/2005, 1:12 PM	Manufacturer	0
Test Operator	James C. Akers, PhD	Model Number	0
Test Description	Mic pos #22 halfway between #	Serial Number	0
Comments		Operating Mode	0
		Mounting	0
		Dimensions	L= 0, W= 0, H= 0
Meteorological Information		Voltage (V)	0
Temperature (C)	23.5	Current (A)	0
Humidity (%)	37	Line Freq (Hz)	0
Pressure (KPa)	98.9	RPM	0

Greatest Impulsive Indicator: Pos's 1 through 21 : 1.1 dBA

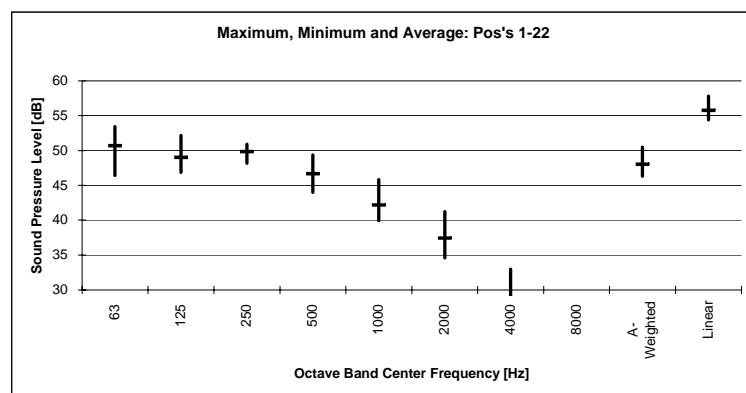
Measurement Information

All sound pressure data reported herein has been obtained in accordance with the procedures specified ISO 11201:1995(E) and NASA SSP 57000 E, except as noted. All data is expressed in decibels(dB) with a reference level of 2×10^{-5} Pa.

Compliance Verification Point

23

Pos	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Octave Band Freq (Hz)	Left Top SPL (dB)	Left SPL (dB)	Left SPL (dB)	Left Mid SPL (dB)	Left SPL (dB)	Left SPL (dB)	Left Btm SPL (dB)	Cntr Top SPL (dB)	Cntr SPL (dB)	Cntr SPL (dB)	Cntr Mid SPL (dB)	Cntr SPL (dB)	Cntr SPL (dB)	Cntr Btm SPL (dB)	Right Top SPL (dB)	Right SPL (dB)	Right SPL (dB)	Right Mid SPL (dB)	Right SPL (dB)	Right SPL (dB)	Right Btm SPL (dB)	Fire Extnng SPL (dB)	Comp Verif SPL (dB)	Below Rack SPL (dB)	External Ref. SPL (dB)	Noise Int. SPL (dB)
63	46	48	50	51	51	52	53	47	49	50	51	52	53	53	47	49	50	51	52	53	53	53	53	57	53	35
125	47	47	47	48	49	50	51	48	47	48	49	50	51	52	47	47	47	49	50	50	52	53	53	58	52	29
250	50	50	50	50	50	50	49	51	51	51	49	48	49	50	50	50	50	49	49	51	50	50	50	58	50	3
500	48	46	46	47	47	49	49	48	46	45	44	45	46	49	48	47	46	45	44	46	49	50	50	55	49	-4
1000	41	40	41	40	42	42	45	42	41	40	42	43	45	45	42	41	40	40	42	43	45	46	45	54	46	-9
2000	37	36	38	36	37	39	41	37	35	36	35	36	39	41	39	36	35	35	37	39	40	41	42	47	41	-17
4000	28	27	26	28	28	30	33	29	27	26	27	27	30	33	28	27	26	26	28	29	32	32	33	38	32	-24
8000	18	17	16	15	16	17	20	20	18	16	15	15	18	22	19	17	16	15	16	17	20	21	22	27	21	-32
A-Weighted	48	47	47	47	48	49	50	48	47	47	47	47	49	50	48	47	47	46	47	48	50	51	51	58	51	13
Linear	55	54	55	55	56	57	57	55	55	55	55	56	57	58	55	55	55	55	56	57	58	58	58	64	58	36
NC (est'd)	44	41	41	42	42	44	44	44	42	41	41	42	43	44	43	42	41	40	40	41	45	45	46	53	45	5



Measurement Uncertainty - ISO 11201 provides an estimate of the standard deviation of reproducibility of 1.0 dBA for a "well-defined" family of machines with broadband noise emission characteristics. ISO 7779 procedures for measurement of emission sound pressure levels and operator and bystander positions provides an estimate of the standard deviation of reproducibility of 1.5 dBA. The ATL maintains an Internal Repeatability Testing program and Program for Estimation of Measurement Uncertainty that is available for client review, upon request. For additional information on uncertainty in each 1/3-octave band, see ISO 7779, Section 8.2 and the ATL Program for Estimation of Measurement Uncertainty."

NASA Glenn Research Center Acoustical Testing Lab (ATL)
ISO 11201 / NASA SSP 57000 Rack Front Noise Emission Test Report

Report Date: 4/13/2005, 1:12 PM

Test Information		Source Information	
Test Name	CIR F 06 Amb-All Quiet 04 Sou-TC 0	Source Type	0
Test Date/Time	4/13/2005, 1:12 PM	Manufacturer	0
Test Operator	James C. Akers, PhD	Model Number	0
Test Description	Mic pos #22 halfway between #7 & #1	Serial Number	0
Comments		Operating Mode	0
		Mounting	0
		Dimensions	L= 0, W= 0, H= 0
Meteorological Information		Voltage (V)	0
Temperature (C)	23.5	Current (A)	0
Humidity (%)	37	Line Freq (Hz)	0
Pressure (KPa)	98.9	RPM	0

Measurement Information

All sound pressure data reported herein has been obtained in accordance with the procedures specified ISO 11201:1995(E) and NASA SSP 57000 E, except as noted. All data is expressed in decibels(dB) with a reference level of 2×10^{-5} Pa.

Compliance Verification Point

Sound Level (dBA)

NC-Rating (Est'd)

Position 23
51
46

Sound Pressure Level Results

Octave Band Center Freq[Hz]	Noise Emission Levels (dB)	Notes
63	53	0
125	53	0
250	50	0
500	50	0
1000	45	0
2000	42	0
4000	33	0
8000	22	0
A	51	
Lin	58	

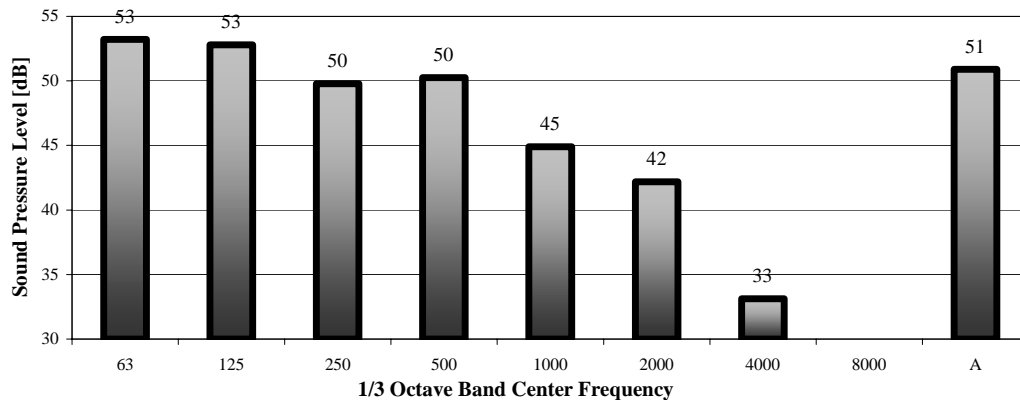
Notes:

0 = Source SPL exceeds Ambient SPL by 3dB

1 = Source SPL within 3dB of Ambient SPL

2 = Source SPL less than or equal to Ambient SPL

Noise Emission Level



■ Position 23

22

ISO 11201 / NASA SSP 57000 Rack Side/Back/Top Noise Emission Test Data Sheet

Report Date: 4/16/2005, 9:29 AM

Test Information

Test Name CIR S 38 Amb-All Quiet 12 Sot
Test Date/Time 4/16/2005, 9:29 AM
Test Operator James C. Akers, PhD
Test Description Rack external monitoring mic
Comments

Source Information

Source Type
Manufacturer
Model Number
Serial Number
Operating Mode
Mounting 0
Dimensions L= 0, W= 0, H= 0
Voltage (V) 0 **Current (A)** 0
Line Freq (Hz) 0 **RPM** 0

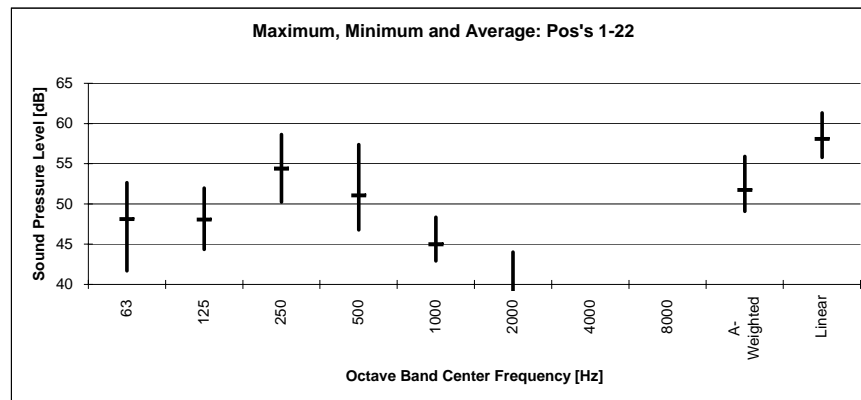
Meteorological Information

Temperature (C) 23.1
Humidity (%) 37
Pressure (KPa) 100.5
Greatest Impulsive Indicator Pos's 1 through 21 : 1.4 dBA

Measurement Information

All sound pressure data reported herein has been obtained in accordance with the procedures specified ISO 11201:1995(E) and NASA SSP 57000 E, except as noted. All data is expressed in decibels(dB) with a reference level of 2*10E-5 Pa.

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Side	Left	Left	Left	Left	Left	Left	Back	Back	Back	Back	Back	Back	Right	Right	Right	Right	Right	Right	Top	Top	Top	Top	TBD	TBD	External	Noise
Location	Frnt	Frnt	Frnt	Back	Back	Bck	Left	Left	Left	Right	Right	Right	Back	Back	Back	Frnt	Frnt	Frnt	Left	Left	Right	Right			Ref	Intrusion
Oct. Freq. (Hz)	Top SPL (dB)	Mid SPL (dB)	Bttm SPL (dB)	Top SPL (dB)	Mid SPL (dB)	Bttm SPL (dB)	Top SPL (dB)	Mid SPL (dB)	Bttm SPL (dB)	Top SPL (dB)	Mid SPL (dB)	Bttm SPL (dB)	Top SPL (dB)	Mid SPL (dB)	Bttm SPL (dB)	Top SPL (dB)	Mid SPL (dB)	Bttm SPL (dB)	Frnt SPL (dB)	Back SPL (dB)	Frnt SPL (dB)	Back SPL (dB)	SPL (dB)	SPL (dB)	SPL (dB)	n SPL (dB)
63	50	52	51	49	51	50	44	45	49	45	47	49	49	52	53	50	52	53	42	42	42	43	77	72	53	34
125	47	47	45	47	46	44	50	47	49	50	48	49	47	47	45	47	48	46	52	52	52	52	77	77	52	21
250	50	53	53	50	53	52	55	58	54	56	59	55	52	55	53	52	54	53	57	56	58	57	76	73	50	0
500	50	49	50	50	49	48	54	51	52	51	50	52	49	50	47	47	48	49	56	57	57	57	70	66	48	-6
1000	45	43	46	45	45	46	44	43	45	43	43	45	45	44	44	43	43	46	48	48	47	48	66	66	46	-14
2000	40	37	38	38	39	39	40	37	36	40	37	36	37	37	37	39	38	37	44	43	42	43	62	62	41	-22
4000	32	30	30	33	34	31	31	31	31	31	31	31	28	28	29	28	28	29	30	33	31	33	58	54	32	-29
8000	22	19	21	21	21	21	23	24	23	23	24	23	21	20	20	20	18	19	22	23	22	22	48	40	21	-37
A-Weighted	50	50	51	50	51	50	52	53	51	52	53	52	50	51	50	49	50	51	55	56	56	56	72	71	50	8
Linear	56	57	57	56	57	56	59	60	58	58	60	58	56	58	57	56	58	57	61	61	61	61	82	80	58	35



Note: "Side" is reckoned as you face the Rack Front.
 Location is reckoned facing the rack surface in question.

ISO 11201 / NASA SSP 57000 Rack Side/Back/Top Noise Emission Test Report

Report Date: 4/16/2005, 9:29 AM

Test Information

Test Name CIR S 38 Amb-All Quiet 12 Sou-TC 01
Test Date/Time 4/16/2005, 9:29 AM
Test Operator James C. Akers, PhD
Test Description Rack external monitoring mic, pos #2
Comments

Source Information

Source Type
Manufacturer
Model Number
Serial Number
Operating Mode
Mounting 0
Dimensions L= 0, W= 0, H= 0
Voltage (V) 0 **Current (A)** 0
Line Freq (Hz) 0 **RPM** 0

Meteorological Information

Temperature (C) 23.1
Humidity (%) 37
Pressure (KPa) 100.5

Measurement Information

All sound pressure data reported herein has been obtained in accordance with the procedures specified ISO 11201:1995(E) and NASA SSP 57000 E, except as noted. All data is expressed in decibels(dB) with a reference level of 2×10^{-5} Pa.

Compliance Verification Point**Sound Level (dBA)****NC-Rating (Est'd)**

Position 21
56
54

Sound Pressure Level Results

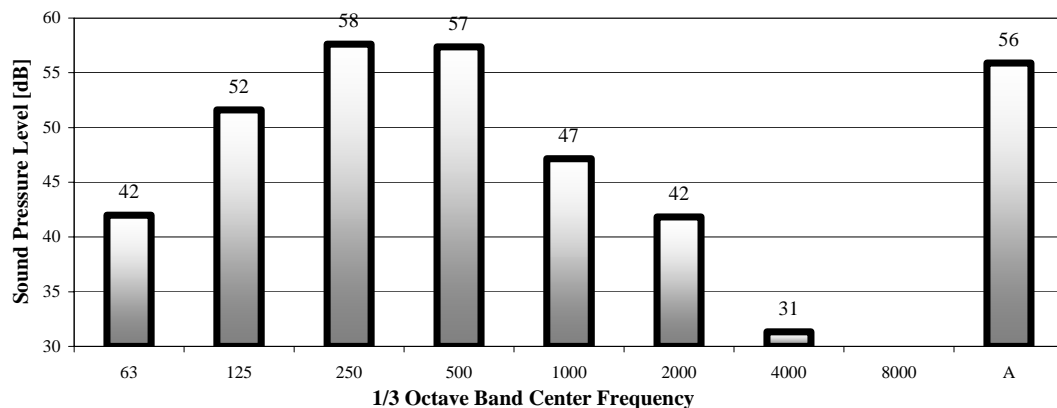
Octave Band Center Freq[Hz]	Noise Emission Levels (dB)	Notes
63	42	0
125	52	0
250	58	0
500	57	0
1000	47	0
2000	42	0
4000	31	0
8000	22	0
A	56	
Lin	61	

Notes:

0 = Source SPL exceeds Ambient SPL by 3dB

1 = Source SPL within 3dB of Ambient SPL

2 = Source SPL less than or equal to Ambient SPL

Noise Emission Level

■ Position 21

22